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US ARMY TEST & EVALUATION COMMAND

FINAL REPORT OF

MILITARY POTENTIAL TEST

(COMPARATIVE EVALUATION) OF

OMNI-RANGE RECEIVER SETS

USATECOM PROJECT NO. 4-4-4315-01

DA PROJECT NO. 1G641203D526

4 FEB 1965

J E Walsby
USAADTA (PROJ)
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US ARMY

AVIATION TEST BOARD

FORT RUCKER, ALABAMA

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UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

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MILITARY POTENTIAL TEST (COMPARATIVE EVALUATION) OF OMNI-RANGE RECEIVER SETS

16 USATECOM [redacted] 4-4-4315-01,

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A. J. RANKIN
COLONEL, ARMOR
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ABSTRACT

The US Army Aviation Test Board, US Army Electronic Proving Ground, and US Army Human Engineering Laboratory conducted the Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets during the period 1 October - 15 December 1964. The test was conducted in the vicinities of Fort Rucker, Alabama, and Fort Huachuca, Arizona. All the test items met the size and weight requirements. Salmon could operate at, and well below, FAA-established minimum reception altitudes and at greater range than Aqua and Maroon. None of the sets met all of the SCL and TSO requirements. The technical requirements were inadequate. All the test items could be maintained with standard avionics test equipment and tools. Aqua had nine deficiencies and Maroon and Salmon each had six deficiencies. From the standpoint of human engineering, Salmon was rated the best of the systems evaluated. It was concluded that all of the systems tested should be suitable for Army use when the deficiencies are corrected; that of the systems tested, Salmon has the greatest and Maroon the least military potential; that technical requirements used were not a satisfactory standard for technical evaluations; and that correction of the shortcomings would enhance the suitability of the test items. It was recommended that the deficiencies be corrected and the selected system undergo further testing before acceptance by the Army as a standard item; the shortcomings be corrected as technically and economically feasible; and the technical requirements be revised to provide clear, realistic specifications in keeping with the state of the art in airborne navigation equipment.

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

FINAL REPORT OF

MILITARY POTENTIAL TEST (COMPARATIVE EVALUATION)

OF OMNI-RANGE RECEIVER SETS

USATECOM PROJECT NO. 4-4-4315-01

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UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

REPORT OF TEST

USATECOM PROJECT NO. 4-4-4315-01

MILITARY POTENTIAL TEST (COMPARATIVE EVALUATION) OF

OMNI-RANGE RECEIVER SETS

SECTION 1 - GENERAL

1.1. REFERENCES.

a. Technical Manual TM 11-5826-207-10, Department of the Army, June 1959.

b. Technical Manual TM 11-5826-207-50, Department of the Army, June 1959.

c. Technical Manual TM 11-5826-215-12, Department of the Army, 21 August 1961.

d. Technical Manual TM 11-5826-215-35, Department of the Army, 21 August 1961.

e. Letter, Assistant Secretary of the Army (ASA), Installation and Logistics (Mr. Ignatius), 13 November 1963, subject: "FY 64 Procurement of Avionic Equipment," with five Indorsements.

f. Technical Requirements:

(1) Signal Corps Letter (SCL) 8014, "Receiver Set, Radio, Units of (Replacement of AN/ARN-30( ))," US Army Electronics Command, 7 February 1964, with Amendment No. 2 dated 12 August 1964.

(2) Federal Aviation Agency (FAA) Technical Standard Order (TSO) C36a.

(3) Federal Aviation Agency TSO C38a.

(4) Federal Aviation Agency TSO C40a.

g. Letter, AMSEL-AV-E, Headquarters, US Army Electronics Command, 24 February 1964, subject: "Modernization Program for OMNI-Range Receivers, Automatic Direction Finding Equipment and Lightweight HF Aircraft Radio Sets," with one inclosure.

h. Memorandum for Record, STEBG-TPAV, US Army Aviation Test Board, 15 April 1964, subject: "Test Requirements Conference, Military Potential (Comparative Evaluation) Test of the OMNI, ADF and HF Radios, USATECOM Project No. 4-4-4315/4316/4317."

i. Memorandum for Record, STEBG-TPAV, US Army Aviation Test Board, 29 April 1964, subject: "USAECOM/USATECOM Planning Conference for Military Potential Test of OMNI, ADF and HF Radios, USATECOM Project No. 4-4-4315/4316/4317."

j. Message, AMSEL-RD-SRI-5-27, US Army Electronics Command, 6 May 1964, subject: "Confirming Telephone Message to Major Treece on 1 May 1964 Regarding Military Potential Test of OMNI and ADF Receivers."

k. Plan of Test, USATECOM Project No. 4-4-4315-( ), "Military Potential Test (Comparative Evaluation) of OMNI-Range Receiver Sets," US Army Aviation Test Board, 15 June 1964, as revised.

l. Message, STEBG-PR, US Army Aviation Test Board, 19 June 1964, subject: "Comparative Evaluation OMNI and ADF Navigation Equipments."

m. Minutes of Conference held at USAECOM, Fort Monmouth, N.J., 1-2 July 1964, subject: "Evaluation of Commercial Equipment to Replace the AN/ARN-30 OMNI and AN/ARN-59 ADF Radio Sets."

n. Interim Report, USATECOM Project No. 4-4-4315-( ), "Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets," US Army Aviation Test Board, 16 December 1964.

1.2. AUTHORITY.

1.2.1. Directives.

1.2.1.1. Letter, AMSTE-BG, US Army Test and Evaluation Command, 17 March 1964, subject: "Test Directive, USATECOM Project No. 4-4-4315-( ), Military Potential Test (Comparative Evaluation) of OMNI-Range Receiver Sets."

1.2.1.2. Letter, AMSTE-BG, US Army Test and Evaluation Command, 22 May 1964, subject: "Supplement Test Directive, USATECOM Project No. 4-4-4315-( ), Military Potential Test (Comparative Evaluation) of OMNI-Range Receivers."

1.2.2. Purpose.

To develop test data for use as a basis for selection of the most promising or suitable system or systems for Army use.

1.3. TEST OBJECTIVES.

To determine the Omni-Range Receiver Sets':

a. Physical characteristics.

b. Performance in flight.

c. Technical suitability.

d. Maintenance and support requirements.

e. Deficiencies.

f. Human engineering characteristics.

1.4. RESPONSIBILITIES.

1.4.1. US Army Aviation Test Board. The US Army Aviation Test Board (USAAVNTBD) as the executive test agency was responsible for:

a. Conducting such tests as required to establish operational suitability for each omni-range receiver.

b. Preparing the test plan and test report.

1.4.2. US Army Electronics Proving Ground. The US Army Electronics Proving Ground (USAEPG) was a participating test agency (PTA) and was responsible for:

a. Conducting such tests as required to establish technical suitability for each omni-range receiver.

b. Assisting in the preparation of the test plan and test report.

1.4.3. US Army Human Engineering Laboratory. The US Army Human Engineering Laboratory (USAHEL) was a PTA and was responsible for:

a. Conducting such tests as required to establish human factors suitability for each omni-range receiver.

b. Assisting in the preparation of the test plan and test report.

1.5. DESCRIPTION OF MATERIEL.

An omni-range receiver is an airborne navigational radio set designed to operate in the very high frequency (VHF) range of 108 to 126.95 megacycles. It receives signals transmitted by VHF visual omni-ranges (VOR), visual aural ranges (VAR), or localizer (LOC) stations which are a part of the instrument landing system (ILS). The received signal is displayed on a visual indicator to provide the operator with navigation information. The system may also be used to receive radio communications within their frequency range. Following are brief descriptions of the test items (detailed descriptions are contained in appendix III, section 4):

1.5.1. Aqua.

The Aqua system is approximately 90 percent transistorized, uses electromechanical tuning, weighs 22.75 pounds, and consists of the following components (figure 1):

a. Control panel.

b. Course indicator.

c. Receiver unit.

d. Navigation unit.

1.5.2. Maroon.

The Maroon system is approximately 80 percent transistorized, uses electromechanical tuning, weighs 22 pounds, and consists of the following components (figure 2):

a. Control panel.

b. Course indicator.

c. Receiver unit.

d. Converter unit.

e. Converter unit (radio magnetic indicator (RMI)).

1.5.3. Salmon.

The Salmon system is completely transistorized, uses electro-diode tuning, weighs 14.5 pounds, and consists of the following components (figure 3):

a. Control panel.

b. Course indicator.

c. VOR/LOC/RMI navigation unit.

1.6. BACKGROUND.

1.6.1. For the past eleven years, the standard Omni-Range Receiver, AN/ARN-30( ), has been procured from one company. During this period, no tests have been conducted to determine whether the design of this equipment is abreast of the current state of the art. By direction of the Assistant Secretary of Army (Installations and Logistics) (reference e), technical proposals for new designs of OMNI-range receivers were solicited and evaluated.

1.6.2. A conference was held at Fort Rucker, Alabama, in April 1964, with representatives from US Army Test and Evaluation Command (USATECOM), US Army Electronics Command (USAECOM), US Army Electronics Research and Development Laboratory (USAELRDL), USAEPG, and USAAVNTBD. The conference established the general guidance for planning the omni-range receiver tests to be conducted by USATECOM agencies for USAECOM.

1.6.3. In May 1964, industry was solicited by USAECOM to determine the "off-the-shelf" systems available for military potential testing. The USAECOM selected three omni-range receiver systems of different manufacturer and these were installed by the respective manufacturers (at Fort Rucker, Alabama) in JUH-19D helicopters and RU-8D airplanes.

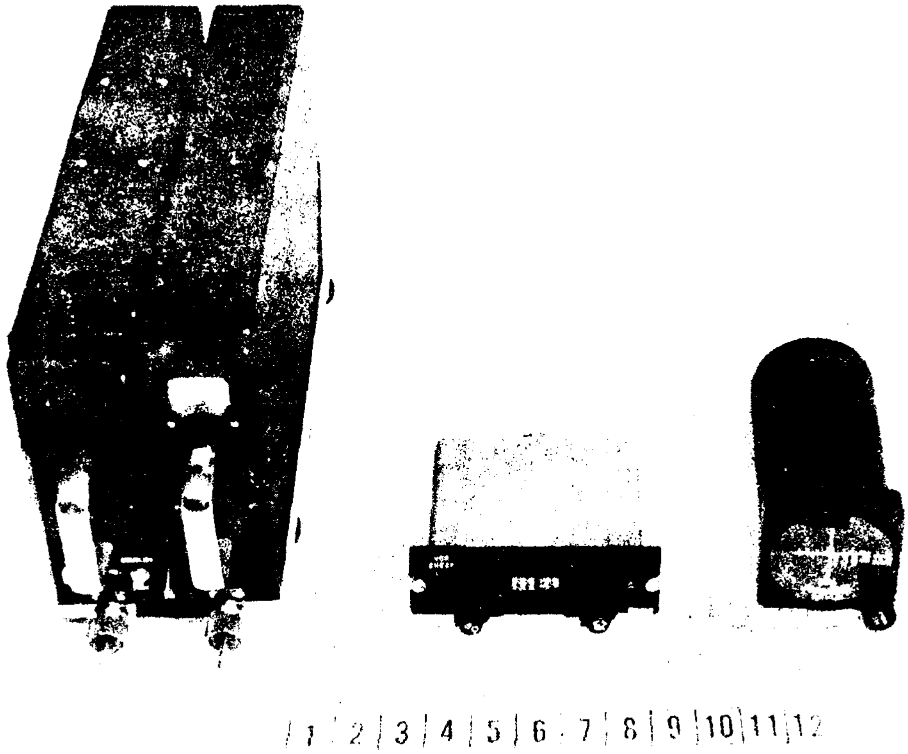

Figure 1. Aqua Omni-Range Receiver Set

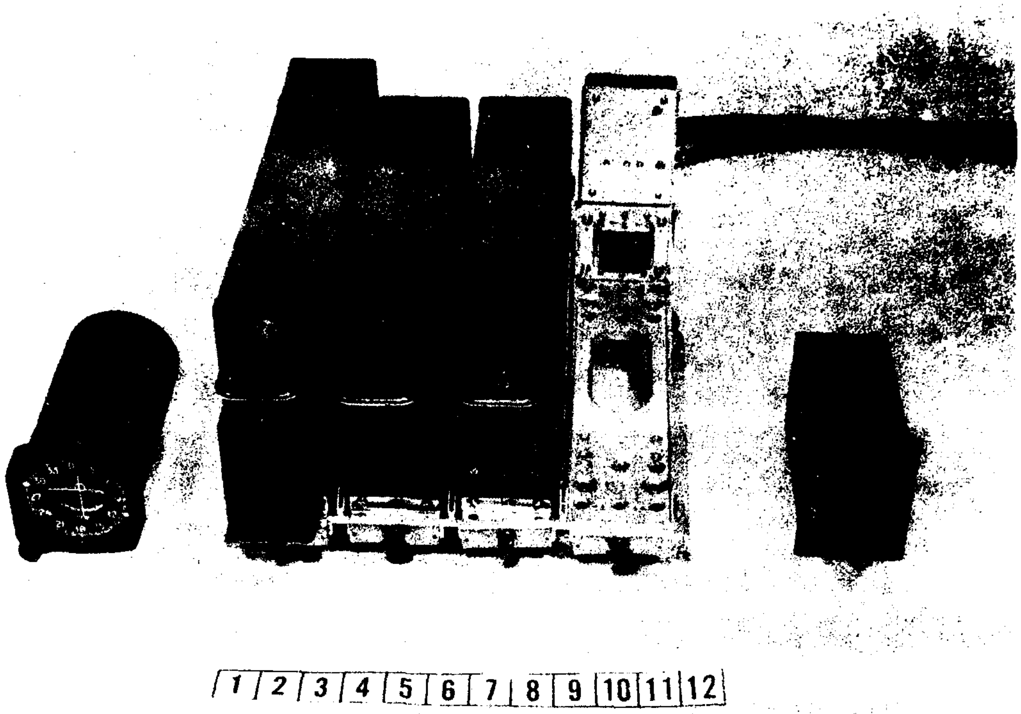

Figure 2. Maroon Omni-Range Receiver Set

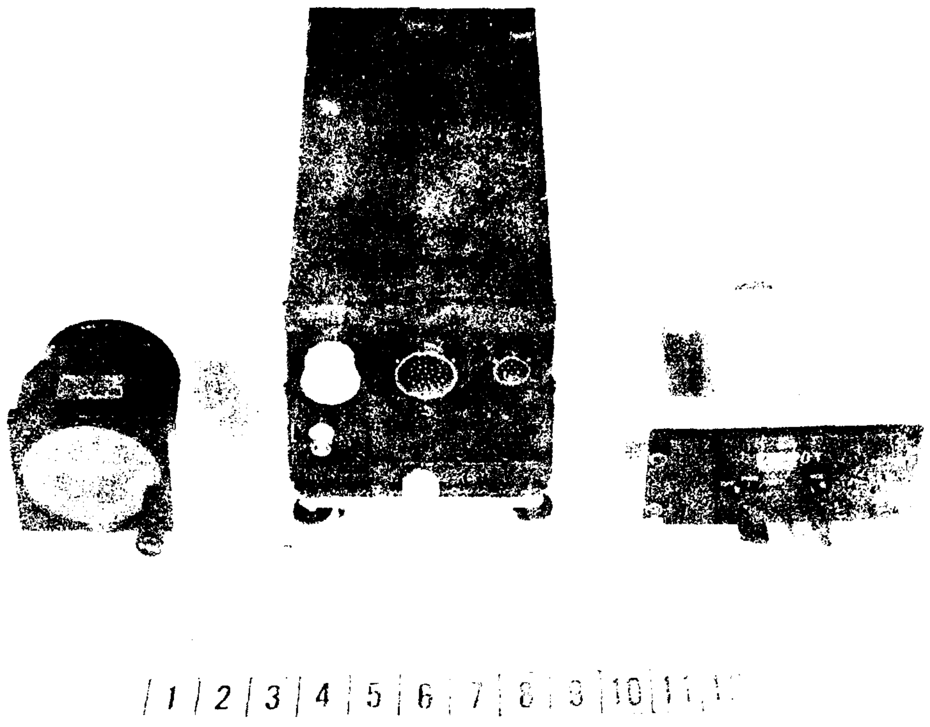

Figure 3. Salmon Omni-Range Receiver Sets

1.7. FINDINGS.

1.7.1. Physical Characteristics.

All the test items met the size and weight requirements. Salmon weighed 33 percent less than Maroon and 39 percent less than Aqua.

1.7.2. Performance in Flight.

Salmon could operate at, and well below, FAA-established minimum reception altitudes (MRA) and at greater ranges than the other test items. Because of a lack of internal lighting, bearing indicators of all test items were difficult to read during darkness. Salmon and Aqua had excessive rotor modulation.

1.7.3. Technical Suitability.

Tests to determine technical suitability were conducted by USAEPG. A summary of their findings is as follows (for complete reports, see part A, section 3):

1.7.3.1. None of the sets met all of the SCL and TSO requirements; however, the areas in which they failed were considered shortcomings.

1.7.3.2. Technical requirements were inadequate.

1.7.4. Maintenance and Support Requirements.

All the test items could be maintained with standard avionics test equipment and tools. An Aviation Electronic Equipment Mechanic (MOS 284.1) could perform organizational maintenance without additional training. An Aviation Electronic Equipment Repairman (MOS 284.2) could perform field maintenance after 24 hours of formal training and 16 hours of on-the-job training. Failures occurring during test were considered to be isolated and not subject to repetition, and do not indicate a reliability problem over an extended period.

1.7.5. Deficiencies.

The following deficiencies which would preclude Army acceptance of the equipment were noted:

1.7.5.1. Aqua.

1.7.5.1.1. The system would not operate reliably at minimum reception altitudes, the system when installed in a helicopter had excessive rotor modulation, and speech intelligibility was below normal.

1.7.5.1.2. The course indicator had no internal lighting, the lettering on the warning flag was too small, and too many turns of the selector knob were required in operation of the course selector.

1.7.5.1.3. Controls were not labeled as to function, ganged (concentric) controls did not have similar functions and knobs were not the proper size, and tuning knobs partially masked the frequency dial.

1.7.5.2. Maroon.

1.7.5.2.1. The system would not operate reliably at minimum reception altitudes and the speech intelligibility was below normal.

1.7.5.2.2. The course indicator had no internal lighting.

1.7.5.2.3. The control panel was inadequate because width was not standard, controls were not labeled as to function, ganged (concentric) control knobs were not the proper size, and controls and lettering were not illuminated.

1.7.5.3. Salmon.

1.7.5.3.1. The system, when installed in a helicopter, had excessive rotor modulation.

1.7.5.3.2. The course indicator was inadequate because blue-yellow markings were not provided, reciprocal bearing numerals were too small, and internal lighting was not provided.

1.7.5.3.3. Knobs on the control panel were located too close together, ganged (concentric) controls did not have similar functions, and knobs were too small for use by an operator wearing gloves.

1.7.6. Human Engineering Characteristics.

Human engineering tests were conducted by USAHEL. A summary of their findings follows (for complete report, see part B, section 3):

1.7.6.1. Salmon met the minimum acceptable standards for speech intelligibility. Aqua and Maroon were below the minimum standard.

1.7.6.2. The Salmon control panel was rated the highest of the three units. The Maroon control panel was rated the lowest and was completely unacceptable.

1.7.6.3. The Maroon course indicator was rated the highest of the three units, and the Aqua was rated the lowest.

1.7.6.4. From the standpoint of human engineering, Salmon was rated the best of the systems evaluated.

1.8. CONCLUSIONS.

1.8.1. All of the omni systems tested should be suitable for Army use when the deficiencies listed in appendix II are corrected.

1.8.2. Of the systems tested, the Salmon has the greatest military potential and the Maroon has the least military potential.

1.8.3. Technical requirements used were not a satisfactory standard for technical evaluation of the test items.

1.8.4. Correction of the shortcomings listed in appendix II and parts A and B of section 3 would enhance the suitability of the test items.

1.9. RECOMMENDATIONS.

It is recommended that:

1.9.1. The deficiencies listed in appendix II be corrected and the selected system undergo further testing before acceptance by the Army as a standard item.

1.9.2. The shortcomings listed in appendix II and parts A and B of section 3 be corrected as technically and economically feasible.

1.9.3. The technical requirements be revised to provide clear, realistic specifications in keeping with the state of the art in airborne navigation equipment.

SECTION 2 - DETAILS AND RESULTS OF SUBTESTS.

2.0. INTRODUCTION.

2.0.1. The omni-Range Receiver Sets were tested by the US Army Aviation Test Board (USAAVNTBD), US Army Electronics Proving Ground (USAEPG), and US Army Human Engineering Laboratory (USAHEL) during the period 1 October 1964 through 15 December 1964. Operational testing and human engineering evaluations were performed by the USAAVNTBD and USAHEL at Fort Rucker, Alabama, during an eight-week flight test period. Technical evaluations and testing were performed by the USAEPG at Fort Huachuca, Arizona, and were restricted to bench tests to determine the ability of the test items to fulfill the technical requirement.

2.0.2. The test items were installed in both rotary-wing (JUH-19D) and fixed-wing (RU-8D) aircraft by the respective manufacturers' representatives and released by them prior to the flight testing. The test items were operated during all types of flight conditions (by 24 pilots with varying avionics and pilot experience) requiring utilization of an omni-range receiver or components thereof. A total of 450 hours of flight testing was accomplished during this evaluation.

2.0.3. Each system was tested against SCL-8014 with Amendment No. 2 dated 12 August 1964. If the test item failed to meet this standard, the set was compared with the applicable requirements of Federal Aviation Agency Technical Standard Orders.

2.0.4. All maintenance was performed by Army maintenance personnel assigned to the respective test activities with technical assistance provided by each manufacturer.

2.0.5. Previous plans and reports of test were researched and pertinent information considered.

2.1. PHYSICAL CHARACTERISTICS.

2.1.1. Objective.

To determine the physical characteristics of the OMNI-range receiver sets.

2.1.2. Method.

2.1.2.1. Installation instructions, drawings and diagrams, and the installation itself were examined for adequacy and for any special mounts and/or special wiring required for installation and operation.

2.1.2.2. Components were examined, weighed, and measured. The total volume and weight of each system were calculated, recorded, and compared with those specified in the Technical Requirements.

2.1.2.3. Components were examined for unusual physical features that would add to or detract from the system's suitability. Attention was directed to the physical characteristics of the design and location of controls, indicators, lighting, and readouts.

2.1.3. Results.

2.1.3.1. All the manufacturers' installation instructions, drawings, diagrams, and installations were adequate. None of the publications were in prescribed Army technical manual format.

2.1.3.2. The Maroon control panel was of a non-standard width and required a special bracket for installation in a standard control panel console. No special mounts or wiring were required for the installation or operation of the Salmon or Aqua.

2.1.3.3. All the test items met the criteria for size, weight, and volume. See part A, section 3, for dimensions, weight, and volume of each system.

2.1.3.4. An excessive number of turns was required to select a desired bearing on the Aqua bearing indicator because of the gear ratio between the OMNI bearing selector and the radial indicator. The Salmon combined all controls necessary for operation of a dual OMNI installation into a single control panel for ease of operation. No internal lighting was provided on any of the bearing indicators.

2.1.3.5. The Aqua was approximately 90-percent transistorized and employed electro-mechanical tuning. The Maroon was approximately 80-percent transistorized and employed electro-mechanical tuning. The Salmon was completely transistorized and employed electro-diode tuning.

2.1.3.6. Aqua had four components, Maroon five, and Salmon three.

2.1.4. Analysis.

All the test items met the size and weight requirements. The Salmon weighed 39 percent less than Aqua and 33 percent less than Maroon.

2.2. PERFORMANCE IN FLIGHT.

2.2.1. Objective.

To determine the performance of the OMNI-range receivers when operating under flight conditions.

2.2.2. Method.

2.2.2.1. The test-bed aircraft were flown along selected OMNI radials to and from omni stations to determine the maximum usable reception range of the omni-range receiver sets. Simultaneous range tests were conducted in all test-bed aircraft in the same area.

2.2.2.2. All test-bed aircraft were flown over selected ground tracks to and from an omni station to determine the test item's capability for track following and to determine capability of each test item to consistently position an aircraft over a ground fix. The radial indicated by the test item was recorded each time the aircraft was over an FAA-certified airborne check point. At airfields equipped with an FAA-certified ground check point, the aircraft was landed and a ground check was made on the test items. The flight tests were conducted at minimum enroute altitude as published by the Federal Aviation Agency for the ground station being used.

2.2.2.3. The test-bed aircraft were flown over selected omni intersections and omni ground stations to determine the capability of the test items to provide intersection and omni holding information.

2.2.2.4. The test-bed aircraft were flown over omni transmitting stations to determine the capability of the test items to provide a reliable indication of station passage.

2.2.2.5. The test-bed aircraft were flown to determine the VOR, Terminal VOR, and ILS approach suitability of the test items and to

determine repeatability of ground track. The pilot used normal approach procedures, recording course and approximate ground path for each significant point of the procedure.

2.2.2.6. Tests were made to determine identification signal and voice reception capability of the test items. The identification signal received was checked for clarity and possible effect on the course indication. This check was performed while flying on course and within line-of-sight of the ground station while carefully observing the course indicator to determine whether either the code or voice identification affected course indication. The voice broadcast received on VOR frequency was checked for clarity and effect on the course indication in the same manner as the identification checks.

2.2.2.7. The test items were operated in various combinations with other electronic equipment installed in the test-bed aircraft while in flight to determine whether mutual interference existed. Dual test items were installed to determine their ability to operate from one antenna installation.

2.2.2.8. The test-bed aircraft were flown during the hours of daylight, darkness, and adverse weather conditions to determine whether these affected the performance of the test items. The test items were used for track following, holding, station passage, intersection identification, and terminal approaches during the above conditions.

2.2.2.9. The self-test function of the test item was operated throughout the test profile to determine operative condition of the test item and the time and effort required to perform this test.

2.2.3. Results.

2.2.3.1. At 1250 feet absolute altitude over flat terrain, Salmon had an average range of 58 nautical miles, while Aqua and Maroon had an average range of 42 nautical miles.

2.2.3.2. Twenty-five ground checks and twenty-four airborne checks were made on each type equipment with the following results:

2.2.3.2.1. Aqua had errors at airborne and ground check points that ranged from 0 to 2 degrees. The average error at the ground check points was 0.8 degree and at the airborne check points was 0.67 degree.

2.2.3.2.2. Maroon had errors at airborne and ground check points that ranged from 0 to 4 degrees. The average error at the ground check points was 1.7 degrees and at the airborne check points was 0.87 degree.

2.2.3.2.3. Salmon had errors at the airborne and ground check points that ranged from 0 to 4 degrees. The average error at the ground check points was 1.24 degrees and at the airborne check points was 0.76 degree.

2.2.3.3. Aqua and Maroon did not provide reliable navigation information at the minimum reception altitude (MRA) on some legs of the flight profiles. Salmon equipment provided reliable navigation information at and below MRA on all flight tests.

2.2.3.4. All test items provided intersection and OMNI-range holding information within the accuracies stated in paragraph 2.2.3.2. above.

2.2.3.5. All test items gave adequate indication of station passage.

2.2.3.6. All the test items provided adequate navigation information when being used as an approach aid.

2.2.3.7. The ability of each test item to receive voice and identification signals was acceptable; however, the range at which each test item could receive these signals varied significantly (see paragraph 2.2.3.1.).

2.2.3.8. No adverse effects were noted when the test items were operated with other installed avionics equipment. There was a degradation of performance when two receivers (dual OMNI installation) were connected to a common antenna.

2.2.3.9. Operation at night and during adverse weather conditions had no noticeable effect on the navigational information. However, the pilot had difficulty interpreting the information during darkness because of a lack of internal lighting in the bearing indicators.

2.2.3.10. No adverse effects (from vibrations or sling loads) were noted in any of the test items when operated in helicopters. Aqua and Salmon had excessive rotor modulation (3 to 10 degrees).

2.2.3.11. Salmon and Aqua self-test features were adequate and required a minimum amount of time and effort to use. The Maroon did not provide a self-test feature.

2.2.4. Analysis.

The Salmon could operate at, and well below, FAA-established minimum reception altitudes and at greater ranges than the other test items. Because of the lack of internal lighting, bearing indicators of all test items were difficult to read during darkness. Rotor modulation of Salmon and Aqua was caused by inadequate filtering for a specific helicopter and according to the manufacturers, would require a minor modification.

2.3. MAINTENANCE AND SUPPORT REQUIREMENTS.

2.3.1. Objective.

To determine the maintenance and support requirements for the Omni-Range Receiver Sets.

2.3.2. Method.

2.3.2.1. The physical installation was inspected to determine unusual maintenance and special support items required to install and maintain the test item.

2.3.2.2. The total operating time of the installed test items was recorded. All failures, cause of failures, time required for repairs, replacement parts required, and the effect of the failure on the system operation were recorded as far as practical.

2.3.2.3. The test items were evaluated to determine the ease of maintenance of the components to include: packaging density, location of a failure, difficulty of component change, and availability and accessibility of test points.

2.3.2.4. Tool Kits TK-87/U and TK-88/U and standard avionics test equipment were used to perform required maintenance on the test items to determine their adequacy.

2.3.2.5. The components of the test items were evaluated to determine whether non-standard parts, high cost items, or critical parts were required for replacement and to determine the availability of replacement parts in the Army supply channels.

2.3.2.6. The test items were evaluated to determine the scope of avionics maintenance and the skill level (MOS) required.

2.3.2.7. The test items were evaluated to determine the design adequacy of connectors and plugs to provide a safe go-no-go type of connection. Self-test features were examined for adequacy, readability, and desirability.

2.3.2.8. Records were maintained to reflect the man-hours and number of personnel required to identify malfunctions, correct these malfunctions, and perform required inspections. The intervals of inspection and alignment were determined.

2.3.3. Results.

2.3.3.1. No unusual maintenance or special support items were required to install and maintain the test items. The major units of the test items were readily removed and replaced.

2.3.3.2. See appendix I, section 4, for a detailed list of failures, cause of failure, time required for repair, replacement parts, and effect of failure on the system.

2.3.3.3. Each of the test items, although varied in design and construction, provided numerous accessible test features designed to simplify maintenance operations. No problems in locating failure or changing circuit components were encountered with any of the test items. Because of circuit arrangement, and component identification and spacing, failure location and circuit component changes at field maintenance level were more readily accomplished on the Aqua. Organizational (flight line) maintenance was easier to perform on the Salmon because of the packaging of the majority of the system circuitry in one unit, whereas Aqua was packaged in two units and Maroon in three units.

2.3.3.4. The TK-87/U and TK-88/U Tool Kits were adequate for organizational and field maintenance. Test equipment presently utilized to maintain existing OMNI-range equipment was adequate for organizational and field maintenance.

2.3.3.5. The percentage of parts standardization was not determined. Information required to cross reference the manufacturer's part numbers to Federal Part or Stock Numbers was not available. A high percentage of the sub-component parts (transistors, capacitors, resistors, etc.) utilized in all of the test items were commonly used electronic components which are in normal Army supply channels. Modules, sub-circuits, and assemblies in all of the test items were non-standard

and unavailable through normal supply channels. No maintenance package was furnished.

2.3.3.6. An Aviation Electronic Equipment Mechanic (MOS 284.1) could perform organizational maintenance without additional training. An Aviation Electronic Equipment Repairman (MOS 284.2) could perform field maintenance after 24 hours of formal training and 16 hours of on-the-job training.

2.3.3.7. Each of the test items contained connectors and plugs which provided a quick, safe go-no-go type of connection. All of the test items were readily removed and replaced. Aqua and Salmon provided a self-test feature which was readable and desirable. Maroon did not provide a self-test feature.

2.3.3.8. Existing periodic maintenance inspection intervals for airborne electronic equipment applied to each of the test items. Maintenance data collected were not sufficient to warrant any change in the existing inspection intervals or personnel requirements.

2.3.4. Analysis.

All the test items could be maintained with standard avionics test equipment and tools. Failures shown in appendix I, section 4, were considered to be isolated and not subject to repetition, and do not indicate a reliability problem over an extended period.

2.4. DEFICIENCIES.

2.4.1. Objective.

To determine whether any deficiencies exist which would preclude Army acceptance of the omni-range receiver sets.

2.4.2. Method.

Test results were analyzed in detail to determine whether disqualifying deficiencies exist in the test items.

2.4.3. Results.

2.4.3.1. Aqua had nine deficiencies and Maroon and Salmon each had six deficiencies. A detailed list of these deficiencies, together with suggested corrective action, is contained in appendix II.

2.4.3.2. Shortcomings discovered during the test are contained in appendix II of section 4, and parts A and B of section 3.

2.4.4. Analysis.

Not applicable.

SECTION 3

REPORTS FROM OTHER TEST AGENCIES

PART A - USAEPG REPORT

PART B - USAHEL REPORT

Part A

USAEPG Report

MILITARY POTENTIAL TEST

OF

OMNIRANGE RECEIVING SETS

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U. S. ARMY [illegible] PROVING GROUND
FORT HUACHUCA, ARIZONA

FINAL REPORT
OF
MILITARY POTENTIAL TEST
(COMPARATIVE EVALUATION)
OMNIRANGE RECEIVING SETS

DA PROJECT 1-G-6-50212-D-326-08

USATECOM PROJECT 4-4-4315-02

USAEPG PUBLICATION ETA-FR-173

FOR THE COMMANDER:

G. D. ELLERSON
Colonel, Artillery
Deputy Commander

SECTION 1. GENERAL

1.1 REFERENCES

See appendix I.

1.2 AUTHORITY

1.2.1 Directive

Letter, AMSTE-BG, U. S. Army Test and Evaluation Command, 17 March 1964, subject: "Test Directive, USATECOM Project No. 4-4-4315-( ), Military Potential Test (Comparative Evaluation) of OMNI-Range Receiver Sets" (appendix II).

1.2.2 Supplement Directive

Letter, AMSTE-BG, U. S. Army Test and Evaluation Command, 22 May 1964, subject: "Supplement Test Directive, USATECOM Project No. 4-4-4315( ), Military Potential Test (Comparative Evaluation) of OMNI-Range Receivers" (appendix II).

1.3 TEST OBJECTIVES

1.3.1 Purpose

The purpose of this Category II test was to obtain data to be used as an input to the overall Military Potential Test (Comparative Evaluation). This overall test will be the basis for selecting suitable omnirange equipment for Army air navigation.

1.3.2 Objectives

To conduct bench tests to determine physical and operational characteristics, technical suitability, and deficiencies of selected commercially-designed omnirange receiving sets. (SCL 8014, as amended, and FAA Technical Standard Orders (TSO's) C36a, C38a, and C40a were used as criteria.)

1.4 RESPONSIBILITIES

1.4.1 U. S. Army Aviation Test Board (USAAVNTBD), Fort Rucker, Alabama, Coordinating Test Agency (CTA) was responsible for reviewing specifications and available data to determine tests required to evaluate the systems, conducting tests and tasks required to establish the degree to which each receiver meets Army requirements, and preparing and publishing the Plan of Test and the Report of Test.

1.4.2 U. S. Army Electronic Proving Ground (USAEPG) as Participating Test Agency (PTA), was responsible for conducting bench tests at Fort Huachuca, Arizona, and for furnishing input data to USAAVNTBD.

1.4.3 U. S. Army Aviation Test Activity (USAATA) Edwards Air Force Base, California, (PTA) was responsible for reviewing specifications and available test data to determine flight testing needed to qualify the equipment, conducting flight tests necessary to establish performance and airworthiness and, as required, assisting in preparation of Plan of Test and Report of Test.

1.5 DESCRIPTION OF MATERIEL

1.5.1 The omnirange equipment is an aircraft radio set designed to operate in the VHF range of 108 to 126.95 megacycles (as changed from 135 megacycles by amendment 2 to SCL 8014) and to receive signals transmitted by VHF omnirange (VOR), visual aural range (VAR) or localizer ground stations. The receiver signal is converted into usable information and presented on a display indicator to provide the operator with navigation information. The system is also capable of simultaneous reception of voice communications.

1.5.2 For purposes of this test report, the test items from the three manufacturers are referred to in color code (Salmon, Aqua, and Maroon).

1.5.3 The nominal input power is 27.5 vdc with channel selection by means of a universal control accessible to the pilot. The converter for driving the radio magnetic indicator (RMI) is an integral

part of the receiver. The equipment is designed for a push-to-test function to test the manual and automatic VOR instrumentation with a minimum of time and energy.

1.5.4 Synchros and associated servo systems utilized 26 vac, 400 cps. The AC power was derived from sources external to the VHF, NAV, COMM system -- from a central instrument transformer provided elsewhere in the aircraft.

1.5.5 The equipment, less antenna and cabling, was designed for minimum weight and installation space not to exceed 26 pounds and 1200 cubic inches.

1.6 BACKGROUND

For the past eleven years the Omni-Range Receiver AN/ARN-30 has been procured from one company. To insure that equipment contains current state-of-the-art design features, the Assistant Secretary of the Army, on 13 November 1963, directed that future procurement be made by competitive selection.

Before this action could be implemented, however, it was decided in a meeting at USAMC Headquarters, 5 June 1964, to procure replacement items without comparative testing. This was planned so that the required equipment could be procured in sufficient time to meet the FY-66 "dock time" of the procured aircraft. It was also decided to use the minimum technical requirements of the current sets as criteria. Obviously, these procedures would not assure the Army of better equipment since the final selection would be based on "paper" evaluation and price. A few Army personnel outside AMC Headquarters agreed that this would retard Army aviation several years.

A message (USAAVNTBD, STEB-PR 6-61) dated 19 June 1964 to AMC proposed that AMC perform limited testing on the Omni-Range Receiver set within a 6-week period, to include engineering tests. However, at the Fort Monmouth meeting held 1 July 1964, it was determined that USAAVNTBD would retain executive responsibility; Fort Rucker would perform the service tests, and USAEPG would conduct bench tests at Fort Huachuca (using duplicate equipment to decrease time and money).

Representatives of AMC, at a meeting in Fort Rucker 17 November 1964, elected that the AN/ARN-30 would not be used in the military potential tests for comparative evaluation.

1.7 FINDINGS

1.7.1 None of the sets met all of the SCL and TSO requirements. Following is a summary showing the compliance of the test items with the requirements (see appendix III for detailed findings):

TEST	SALMON SCL	SALMON TSO	AQUA SCL	AQUA TSO	MAROON SCL	MAROON TSO
Design Features	Yes	N/A	Yes	N/A	No	N/A
Effect of Input Voltage Variations on Receiver Power Supply	Yes	N/A	Yes	N/A	Yes	N/A
Power Drain	No	N/A	No	N/A	No	N/A
Audio Frequency Response	Yes	Yes	Yes	Yes	Yes	Yes
Receiver Sensitivity	Yes	Yes	Yes	Yes	Yes	Yes
Automatic Volume Control Operation	Yes	Yes	Yes	Yes	Yes	Yes
Audio Output Distortion	Yes	Yes	No	Yes	No	Yes
Gain of Receiver Output	Yes	Yes	No	Yes	Yes	Yes
Channel Selection Time	Yes	Yes	Yes	Yes	Yes	Yes
Spurious Sidebands	No	No	No	No	No	No
Noise Level	Yes	Yes	Yes	Yes	No	No
Bearing Accuracy	Yes	Yes	Yes	Yes	Yes	Yes

TEST	SALMON SCL	SALMON TSO	AQUA SCL	AQUA TSO	MAROON SCL	MAROON TSO
Deflection Linearity	No	No	No	No	No	No
Flag Alarm Signal	No	No	Yes	Yes	Yes	Yes
Instrumentation Output	Yes	N/A	Yes	N/A	Yes	N/A
Squelch Control	No	N/A	No	N/A	No	N/A
ILS Localizer Alarm Signal	Yes	Yes	Yes	Yes	Yes	Yes
Physical Characteristics	Yes	N/A	Yes	N/A	Yes	N/A

REMARKS: No safety hazards were found on any of the sets. Fast warmup was observed on all sets.

1.7.2 A deficiency was discovered on the Maroon set after approximately two hours of operation. The set had extremely low sensitivity on both the navigation and communication channels. The manufacturer's representative corrected the deficiency by replacing a defective Zener diode in the set.

1.7.3 In attempting to disconnect the automatic volume control on the Salmon set, the manufacturer's representative unintentionally caused the set to malfunction resulting in extremely low audio output power. The set was removed to the factory and then returned to USAEPG. If any corrective action was taken at the factory, USAEPG was not apprised. All bench tests were performed on the test item after its return to USAEPG.

1.7.4 Technical requirements were inadequate in the following areas

a. There were no criteria for safety or allowable warm-up time.

b. Statements of criteria were difficult to interpret because of the lack of definitions of terms and wordy, inadequate specifications.

c. Specific output loads and output power levels were specified sometimes, while at other times the output level was to be adjusted to "rated output" with no specified load requirement. In addition, rated output for certain levels of modulation and frequency ranges are not published by the manufacturers of the equipment.

1.8 CONCLUSIONS

Based on the test findings, it is concluded that:

a. No one of the three test items can be indorsed; neither can one item be rated above the others on the basis of the inadequate criteria provided and the limited bench testing done.

b. SCL 8014 was not a satisfactory standard for evaluating these sets.

1.9 RECOMMENDATIONS

It is recommended that:

a. Complete engineering tests be made before any of the test items are selected for military use.

b. The technical requirements be rewritten to provide clear, realistic specifications in keeping with the latest developments in airborne navigation equipment.

SECTION 2. DETAILS AND RESULTS OF SUBTESTS

2.0 INTRODUCTION

Tests described in this section were performed on each Omni equipment under laboratory conditions as identical as possible. Avionics maintenance was provided by military personnel. Contractor personnel provided initial technical support, monitored any maintenance performed, and certified its validity.

Because of the competitive nature of this comparative evaluation, every effort was made by USAEPG personnel to insure fair and equal treatment to each contractor.

The respective manufacturer of Test Items Salmon, Aqua, and Maroon, provided necessary wiring, connections, and mounts for installation of the test item submitted for test. All operational or user tests were conducted by USAAVNTBD and all bench tests by USAEPG.

2.1 SAFETY

2.1.1 Objective

The objective of this test was to determine whether the test items are safe for installation and operation in Army aircraft.

2.1.2 Criteria

Whenever more than 25 volts are present and exposed, a suitable warning notice shall be prominently displayed. Installation or operation of the test item in Army aircraft shall not create a safety hazard.

2.1.3 Method

2.1.3.1 The test items were checked to determine whether there were any exposed voltages in excess of 25 volts and whether suitable warning notices were displayed.

2.1.3.2 Safety hazards observed during installation and operation of test items were noted.

2.1.4 Results

No voltages above 25 volts were found to be exposed on any of the sets. No safety hazards in installation and operation were noted for any of the sets.

2.1.5 Analysis

All of the sets met the criteria established in paragraph 2.1.2 above.

2.2 WARMUP TIME

2.2.1 Objective

To determine the average time required for each test item to become fully operational from a POWER-OFF condition.

2.2.2 Criterion

The test items shall be capable of stable operation after minimum warmup time.

2.2.3 Method

2.2.3.1 Each test item was in a POWER-OFF condition at least 12 hours before each warmup test.

2.2.3.2 The automatic time counter was turned on the instant that the test item was turned on. When the receiver audio output was stabilized, the counter was turned off and the elapsed time recorded. This test was repeated three times for each test item.

2.2.4 Results

Average warmup time for Salmon was less than 1 second, for Aqua 11 seconds, and for Maroon 11 seconds.

2.2.5 Analysis

All the sets operated satisfactorily after a short warmup interval.

2.3 DESIGN FEATURES

2.3.1 Objective

To determine whether each of the test items contains the required design features.

2.3.2 Criterion

Each test item shall contain the design features listed in Table I.

2.3.3 Method

The appropriate square in the table was checked for each test item.

2.3.4 Results

See Table I.

2.3.5 Analysis

The Salmon and Aqua sets contained all the required design features. The Maroon set contained all the design features except the push-to-test function.

TABLE I. DESIGN FEATURE CHECK-LIST

Design Features	Salmon	Aqua	Maroon
Solid State Devices (Transistors, diodes, varactors, etc.)	Yes	Partially	Partially
Connectors and Pin Coding	Yes	Yes	Yes
Push-to-Test Function	Yes	Yes	No
380 Channels	Yes	Yes	Yes
Input Power: 27.5 Volts DC	Yes	Yes	Yes
Input Power: 26 Volts AC @ 400 cps	Yes*	Yes**	Yes*
Frequency Range 108 to 126.95 mc	Yes	Yes	Yes
Flag-Alarm Signal Device	Yes	Yes	Yes

*Requires AC power only for RMI operation.
**Requires AC power at all times for VOR and RMI operation.

2.4 EFFECT OF INPUT VOLTAGE VARIATIONS ON RECEIVER POWER SUPPLY

2.4.1 Objective

To ascertain the regulatory characteristics of the test item's power supply.

2.4.2 Criteria

In addition to the limits established by MIL-STD-704, the equipment shall be designed to tolerate line variations of up to +10 percent and -20 percent of the input voltage. The equipment shall also tolerate voltage transient spikes up to +100 and -40 volts for a maximum duration of 3 milliseconds.

2.4.3 Method

2.4.3.1 This test was performed by varying the dc input voltage to the omni-range receiver from 22 to 31 volts and ascertaining the capability of the set to respond to these variations.

2.4.3.2 Voltage transient spikes of +100 and -40 volts were applied, and the capability of the set to respond to these spikes was ascertained.

2.4.4 Results

All sets were able to tolerate line variations of +10 and -20 percent of input voltage and voltage transient spikes of +100 and -40 volts for a duration of 3 milliseconds.

2.4.5 Analysis

All sets met the input voltage variation and voltage transient spike requirements.

2.5 POWER DRAIN

2.5.1 Objective

To determine the total power drain of the equipment.

2.5.2 Criteria

The total power drain of the equipment shall not exceed 2.6 amps at 27.5 volts dc and 8.0 volt-amps ac.

2.5.3 Method

The input current and voltage were measured with all electrical equipment in operation.

2.5.4 Results

See Table II.

2.5.5 Analysis

All sets met the dc power-drain requirement, but none of the sets met the ac power requirement. There is no power-drain requirement in the specified Technical Standard Orders (TSO's).

TABLE II. POWER DRAIN

	Maximum Current at 27.5 Volts DC (in amps)	Maximum Current at 26 Volts AC (in amps)	AC Power in Volt-Amperes
Salmon	1.30	0.74	19.24
Aqua	1.30	0.52	13.52
Maroon	2.50	0.58	15.08

NOTE: All measurements were made with all electrical equipment in operation.

2.6 AUDIO FREQUENCY RESPONSE

2.6.1 Objective

To determine the frequency response of the audio amplifying circuit in the test item.

2.6.2 Criterion

The audio frequency response shall not vary more than 6 db when a 50-microvolt signal is modulated 30 percent and the modulation frequency is varied from 350 to 2500 cps.

2.6.3 Method

A 30-percent modulated signal on a 122-mc carrier with an input level of 50 microvolts was applied to the receiver antenna terminals. The RMS audio frequency output voltage was measured across a 300-ohm resistance for the following frequencies (in cycles per second):

350	1000
400	1200
500	1500
600	2000
800	2500

2.6.4 Results

The maximum audio frequency response variation was 4.56 db for the Salmon set, 2.66 db for the Aqua set, and 4.30 db for the Maroon Set.

2.6.5 Analysis

All the sets met the criterion established in paragraph 2.6.2 above.

2.7 RECEIVER SENSITIVITY

2.7.1 Objective

To determine the test item's capability to respond to weak input signals.

2.7.2 Criterion

The level of the input signal to produce a signal-plus-noise ratio of 6 db shall not exceed 3 microvolts modulated 30 percent at 1000 cps.

2.7.3 Method

The input signal amplitude of the Omni-Range Receiver that is required to give a signal-plus-noise output of 6 db above the noise output of the receiver was measured using an input signal of 1000 cps modulated at 30 percent.

2.7.4 Results

See Table III.

2.7.5 Analysis

All the sets met the criterion established in paragraph 2.7.2 above.

TABLE III. RECEIVER SENSITIVITY

Input Signal in Microvolts Needed to Produce a Signal-plus-Noise Ratio of 6 db

	Frequency 108-117.95 mc 30 Percent Modulation	Frequency 118-126.95 mc 30 Percent Modulation
Salmon	0.61	0.75
Aqua	1.80	1.50
Maroon	0.59	0.70

NOTE: Representative carrier frequencies of 114.9 mc and 112 mc were used in the test.

2.8 AUTOMATIC VOLUME CONTROL OPERATION

2.8.1 Objective

To determine the ability of the test item to maintain a constant output signal level when the amplitude of the incoming signal changes.

2.8.2 Criterion

The output audio signal shall not vary more than 10 db with an input signal between 10 to 10,000 microvolts.

2.8.3 Method

A 30-percent, 1000-cps modulated signal on a 122-mc carrier was applied to the receiver antenna terminals. The RMS audio signal output voltage was measured across a 300-ohm resistance for the following input signal voltages.

10 to 100 in 10 microvolt increments.
100 to 1000 in 100 microvolt increments.
1000 to 10,000 in 1000 microvolt increments.

2.8.4 Results

With an input signal varied between 10 and 10,000 microvolts, the output audio signal varied 0.34 db for the Salmon set, 0.48 db for the Aqua set, and 1.70 db for the Maroon set.

2.8.5 Analysis

All the sets met the criterion established in paragraph 2.8.2 above.

2.9 AUDIO OUTPUT DISTORTION

2.9.1 Objective

To determine the output distortion of the audio output circuit.

2.9.2 Criteria

With a 100-microvolt signal varied over the frequency range of 350 to 2500 cps the combined noise and distortion of the receiver output shall not exceed 25 percent on the communication channels when modulated 85 percent; 15 percent on the navigation channels when modulated 30 percent for loads of 150- up to 600-ohm impedance.

2.9.3 Method

2.9.3.1 The percentage of receiver output distortion was measured using a distortion analyzer and a dual beam oscilloscope.

2.9.3.2 The input 100-microvolt signal was varied over the frequency range of 350 to 2500 cps. On the navigation channels the input signal was modulated at 30 percent for loads of 150- up to 600-ohm impedance.

2.9.4 Results

See Table IV.

2.9.5 Analysis

All the sets met the criteria established in paragraph 2.9.2 above on the communications channels. The Salmon set met the criterion on the navigation channels. The Aqua and Maroon sets did not meet the established criteria; however, they both met the requirement as stated in the specified TSO's.

TABLE IV. AUDIO OUTPUT DISTORTION

Maximum Audio Output Distortion in Percent

	Frequency 108-117.95 mc With 30 Percent Modulation at Load Impedances of			Frequency 118-126.95 mc With 85 Percent Modulation at Load Impedance of
	150 ohms	400 ohms	600 ohms	300 ohms
Salmon	12.5%	9.8%	10.2%	10.5%
Aqua	22 %	15 %	12 %	20.6%
Maroon	20 %	8 %	7 %	15.0%

NOTE: Figures shown in table represent maximum distortion in percent obtained with the tested modulating frequencies of 350, 700, 1400, and 2500 cps at the carrier frequencies of 114.9, 118, 122, and 126 mc.

2.10 GAIN OF RECEIVER OUTPUT

2.10.1 Objective

To determine the amount of amplification provided by the audio frequency amplifiers.

2.10.2 Criteria

An input signal of not more than 20 microvolts shall produce a receiver output power into a 300-ohm resistance which is not less than 300 milliwatts with 30-percent modulation for the frequency range of 108 to 117.95 mc, 70 milliwatts with 30-percent modulation, and 300 milliwatts with 85-percent modulation for the frequency range of 118 to 126.95 mc.

2.10.3 Method

2.10.3.1 The amplitude of a 1000-cps input signal was varied from 10 to 25 microvolts in 5-microvolt increments.

2.10.3.2 The input signal was modulated at 30 percent, and the receiver output power into a 300-ohm resistance was measured for the frequency range of 108 to 126.95 mc. The input signal was also modulated at 85 percent over the frequency range of 118 to 126.95, and the output power into a 300-ohm resistance was measured.

2.10.3.3 The measurements were taken with the AVC on.

2.10.4 Results

See Table V.

2.10.5 Analysis

The Salmon and Maroon sets met the criteria established in paragraph 2.10.2 above. The Aqua set met the criterion in the frequency range of 118-126.95 mc with 30 percent modulation. The Aqua set does not provide sufficient gain in the frequency range 108-117.95 mc with 30 percent modulation and in the frequency range 118-126.95 mc with 85 percent modulation. However, the Aqua set did meet the gain requirement as stated in the specified TSO's.

TABLE V. GAIN OF RECEIVER OUTPUT

Output Power Into a 300-Ohms Resistance With
Maximum Input of 20 Micro-Volts

	Frequency Range of 108 to 117.95 mc	Frequency Range of 118 to 126.95 mc	
	30 Percent Modulation	30 Percent Modulation	85 Percent Modulation
Salmon	448 mw	140 mw	475 mw
Aqua	163 mw	95 mw	190 mw
Maroon	852 mw	360 mw	1200 mw

NOTE: Figures shown in table represent the lowest maximum power obtainable at the carrier frequencies of 108, 110, 112, 114, 116, 118, 120, 122, 124, and 126 mc.

2.11 CHANNEL SELECTION TIME

2.11.1 Objective

To determine the cycling time of each test item.

2.11.2 Criterion

The cycling time of the frequency selector shall not exceed 4 seconds.

2.11.3 Method

The time needed to cycle the frequency selector to each adjacent channel was measured.

2.11.4 Results

The channel selection time was less than 1 second for the Salmon set, varied from 1 to 3 seconds for the Aqua set, and varied from less than 1 second to 2.5 seconds for the Maroon set.

2.11.5 Analysis

All the sets met the criterion established in paragraph 2.11.2 above.

2.12 SPURIOUS SIDEBANDS

2.12.1 Objective

To determine whether the spurious sidebands beyond the normal carrier bandwidth can be detected.

2.12.2 Criteria

The level of an input signal on an undesired frequency required to produce rated output shall be at least 60 db greater than that required to produce rated output at the desired channel frequency under the following conditions:

a. When the frequency of the undesired input signal is within the band of 108 to 126.95 mc and is on any frequency.

b. Within ±.005 percent of any assignable channel other than the desired channel to which the receiver is tuned.

c. Within the band of 0.190 and 940 mc.

2.12.3 Method

2.12.3.1 With the receiver tuned to a midband channel, a 30-percent, 1000-cps modulated signal was applied to the receiver input terminals. The input signal was tuned to the frequency of the receiver and the input intensity increased until the rated audio output power was attained.

2.12.3.2 The input signal intensity was then increased by a factor of 1000 and retuned to each of the remaining channels in the 108 to 126.95 mc band. With the same input intensity, the input was tuned from 0.190 to 940 mc, with the exception of 108 to 126.95 mc.

2.12.4 Results

See Table VI.

2.12.5 Analysis

None of the sets met the criteria established in paragraph 2.12.2 above, or the requirement stated in the specified TSO's.

TABLE VI. SPURIOUS SIDEBANDS

Spurious Sidebands Detected at the Following Undesired Frequencies (in mc) With the Receiver Tuned to 122 mc

Salmon	Aqua	Maroon
5.82	61.30	6.43
6.43		6.78
6.78		7.18
7.18		7.60
7.63		8.14
8.14		9.34
10.15		10.13
11.08		11.30
13.50		12.16
15.20		13.50
17.42		15.20
20.40		17.42
24.50		20.30
61.30		24.49
		61.30

NOTE: Frequencies shown in the table are those at which the input signal needed to produce rated receiver output is less than 60 db greater than that needed to produce rated output at the desired frequency. Since there is no published rated power for this frequency at this modulation level, the receivers were adjusted to produce approximately the rated power stated for the navigation channels.

2.13 NOISE LEVEL

2.13.1 Objective

To determine the RF noise level of the test item.

2.13.2 Criteria

The signal-plus-noise-to-noise ratio of the receiver output shall be at least 25 db with the RF input signal range of 100 microvolts to 10,000 microvolts. For this standard, the receiver gain shall be adjusted to produce rated output with the 1000-cps input signal modulated at 30 percent.

2.13.2 Method

A 30-percent, 1000-cps modulated signal on a 122-mc carrier was applied to the receiver antenna terminals. The output voltage across a 300-ohm resistance was measured for each of the following input signal levels measured in microvolts:

100	750	3000
150	1000	5000
300	1500	7500
500	2000	10,000

The output voltage was also recorded without an externally-applied signal.

2.13.4 Results

See Table VII.

2.13.5 Analysis

The Salmon and Aqua sets met the criteria established in paragraph 2.13.2 above. The Maroon set did not meet the criteria at all input levels and did not meet the requirement as stated in the specified TSO's.

TABLE VII. NOISE LEVEL

Input Signal Level in Microvolts	Signal-Plus-Noise-to-Noise Ratio in DB		
	Salmon	Aqua	Maroon
100	25.9	26.7	21.2
150	25.9	27.4	24.1
300	25.9	28.0	23.5
500	25.7	28.9	30.5
750	25.7	29.4	31.2
1000	25.9	29.4	31.2
1500	25.7	29.4	31.2
2000	25.7	29.5	31.2
3000	25.7	30.0	30.1
5000	25.6	30.4	30.1
7500	25.4	30.4	29.4
10,000	25.4	30.4	31.2

NOTE: Readings were made the the representative carrier frequency of 122 mc with 30 percent modulation. Since there is no published rated power for this frequency at this modulation level, the receivers were adjusted to produce approximately the rated power stated for the navigation channels.

2.14 BEARING ACCURACY

2.14.1 Objective

To determine the bearing error

2.14.2 Criteria

At all bearing indications, the bearing error at all combinations of the following variable conditions shall not exceed 2.7 degrees with a statistical probability of 95 percent:

a. A ±.5 percent variation in frequency of the reference and variable phase signal.

b. A ±10 percent variation in primary voltage.

c. Variation in percentage modulation of the carrier by the variable phase signal from 25 to 35 percent.

d. Variation in RF input voltage from 10 to 10,000 microvolts.

e. Variation in power supply frequency throughout the range for which the equipment is designed.

2.14.3 Method

With an omni-signal generator connected to the receiver input and set for zero phase difference, the following factors were varied within the specified ranges, and the indicator deflection in degrees was obtained

VARIABLE	RANGE
Primary Voltage	±10 percent
Modulation Level	25 to 35 percent
Input Voltage	10 to 10,000 microvolts

2.14.4 Results

See Table VIII.

2.14.5 Analysis

Because of limitations in the test equipment, it was not possible to vary the frequency of the reference and variable phase signal or the power supply frequency. Use of statistical analysis with the variables of primary voltage, modulation level, and input voltage, determined that all the sets met the criteria established in paragraph 2.14.2 above.

TABLE VIII. BEARING ACCURACY

Determination of Bearing Error With Statistical Probability of 95 Percent (Numbers in the Table Indicate Degrees)

	Salmon	Aqua	Maroon
$\bar{x}_a$	0	0	0
$\bar{x}_b$	0	0.20	0
$\bar{x}_c$	0.0625	0	0
$\bar{x}_t$	0.0625	0.20	0
σ_a^2	0	0	0
σ_b^2	0.25	0.075	0
σ_c^2	0.0292	0	0
σ_t^2	0.2792	0.075	0
σ_t	0.528	0.274	0
$\bar{x}_t - 2\sigma_t$	-0.99	-0.35	0
$\bar{x}_t + 2\sigma_t$	1.12	0.75	0

NOTE: $\bar{x}_a$ = mean bearing error due to primary voltage variation
$\bar{x}_b$ = mean bearing error due to modulation level variation
$\bar{x}_c$ = mean bearing error due input signal level variation
$\bar{x}_t$ = total mean bearing error
σ_a^2 = variance of bearing due to primary voltage variation
σ_b^2 = variance of bearing due to modulation level variation
σ_c^2 = variance of bearing due to input signal level
σ_t^2 = total variance
$\bar{x}_t \pm 2\sigma_t$ = 95 percent probability range of combined bearing error

2.15 DEFLECTION LINEARITY

2.15.1 Objective

To determine the deflection linearity of the indicating needle.

2.15.2 Criteria

Over the deviation indicator deflection range from 10 percent of standard deflection to maximum deflection, the amount of deflection shall be within 10 percent of being proportional to the difference in phase of the reference and variable phase signals; from that phase producing maximum deflection to a value of 90 degrees, the deflection shall not be less than its maximum value. These standards apply over the range of signal input level from 10 to 10,000 microvolts.

2.15.3 Method

With an omni-signal generator connected to the input terminals the amount of generated phase difference was varied from indicator-centered position to maximum deflection in 2-degree increments of input phase difference. A scale was placed on the instrument face and the amount of needle deflection was recorded. This procedure was repeated for the following input signal levels in microvolts:

10	100	1000	10,000
50	500	5000	

2.15.4 Results

See Table IX. On all sets, the needle deflection did not decrease as the phase difference was increased from that which produced maximum deflection to a 90-degree phase difference.

2.15.5 Analysis

None of the sets met the criteria established in paragraph 2.15.2 or the requirements contained in the specified TSO's.

TABLE IX. DEFLECTION LINEARITY

Deflection Obtained for Input Signal Levels of 10-10,000 Microvolts

	Phase difference in degrees	Range of linearity in units	Actual units of deflection	Is deflection linear
Salmon	2	7.5-22.5	20	Yes
	4	22.5-37.5	35	Yes
	6	37.5-52.5	60	No
	8	52.5-67.5	70	No
	10	67.5-82.5	75	Yes
Aqua	2	8.0-24.0	20	Yes
	4	24.0-40.0	35	Yes
	6	40.0-56.0	60	No
	8	56.0-72.0	74	No
	10	72.0-88.0	80	Yes
Maroon	2	8.5-25.5	15	Yes
	4	25.5-42.5	30	Yes
	6	42.5-59.5	40	No
	8	59.5-76.5	60	Yes
	10	76.5-93.5	85	Yes

NOTE: Phase difference is the difference between the VOR test signal and the receiver bearing indicator. Range of linearity is the range attained when the deflection is proportional to the phase difference within ±10 percent of the deflection obtained from a 10-degree phase difference.

2.16 FLAG ALARM SIGNAL

2.16.1 Objective

To determine whether the flag-alarm signal device is operative in the VOR mode.

2.16.2 Criteria

The flag-alarm signal shall be plainly visible or located in the alarm sector of the "TO-FROM" indicator in the absence of:

2.16.2.1 An RF signal.

2.16.2.2 A 9960-cps modulation on an otherwise standard VHF omnirange (VOR) test signal of 10 to 10,000 microvolts.

2.16.2.3 A 30-cps modulation on an otherwise standard VOR test signal of 10 to 10,000 microvolts.

2.16.2.4 The "alarm" sector shall be entered by the flag alarm signal when the level of a standard VOR test signal is such that the deflection sensitivity is half the sensitivity obtained with a 100-microvolt signal.

2.16.3 Method

The flag-alarm signal was activated by using the conditions described in paragraph 2.16.2.1 through 2.16.2.4.

2.16.4 Results

See Table X.

2.16.5 Analysis

The Salmon set did not meet the criteria established in paragraph 2.16.2 above during loss of 30-cps modulation. The Aqua set and the Maroon set met the criteria.

TABLE X. FLAG ALARM SIGNAL

Flag-Alarm Signal Visible in Absence of:	Salmon	Aqua	Maroon
RF signal	Yes	Yes	Yes
9960 cps modulation on an otherwise standard VOR test signal of 10-10,000 microvolts	Yes	Yes	Yes
30 cps modulation on an otherwise standard VOR test signal of 10-10,000 microvolts	No	Yes	Yes
Level of standard VOR test signal when deflection sensitivity is 1/2 that obtained with 100 microvolt signal	Yes	N/A	Yes

NOTE: The Aqua set is designed such that the VOR needle deflection does not depend on the level of input. Half deflection is therefore not obtainable by varying the level of the input signal. The flag alarm signal will appear when the level of the input signal is too small to provide deflection of the VOR needle.

2.17 INSTRUMENTATION OUTPUT

2.17.1 Objective

To determine whether the output level to operate the test item's indicators was adequate.

2.17.2 Criterion

Suitable and sufficient outputs to operate the standard indicators (such as course deviation indicator (needle and flag), omni-bearing selector, radio magnetic indicator (RMI)(needle and card), etc.) shall be required.

2.17.3 Method

The various outputs that operate the standard indicators were tested.

2.17.4 Results

There were suitable and sufficient outputs to operate standard indicators on the Salmon, Aqua, and Maroon sets.

2.17.5 Analysis

All the sets met the criterion established in paragraph 2.17.2 above.

2.18 SQUELCH CONTROL

2.18.1 Objective

To determine the capability of the test item's squelch control to cut off the receiver when no signal is received.

2.18.2 Criteria

The receiver audio shall open for carriers in excess of 0.2 microvolts when operated in the threshold position and for carriers of 5 microvolts when operated in the maximum squelch condition.

2.18.3 Method

2.18.3.1 The squelch control was tested to determine whether it was adjustable to permit setting the level above which VOR/localizer and communication signals may be accepted.

2.18.3.2 The carrier voltage needed to open the audio circuit when operated at the threshold position, on midposition, and maximum squelch condition were measured.

2.18.3.3 A 30-percent, 1000-cps modulated signal on a 122-mc carrier was applied to the receiver antenna terminals.

2.18.4 Results

See Table XI.

2.18.5 Analysis

The Salmon set has no provision for the external control of squelch operation. Neither the Aqua nor the Maroon sets met the criterion for the squelch control being operated in the threshold position. The Maroon set and the Aqua set met the criterion for the squelch control being operated in the maximum squelch position. There is no requirement for squelch control operation in the specified TSO's.

TABLE XI. SQUELCH CONTROL

Carrier Voltage Needed to Open Audio Circuit
When Squelch Control is Set At:

	Threshold Position	Mid Position	Maximum Position
Salmon	N/A	N/A	N/A
Aqua	0.458 microvolt	0.456 microvolt	1.21 microvolt
Maroon	0.28 microvolt	0.20 microvolt	0.50 microvolt

NOTE: The Salmon set has no provision for external control of squelch operation.

2.19 ILS LOCALIZER RECEIVING TEST

2.19.1 Objective

To determine the deflection linearity of the receiver.

2.19.2 Criteria

Over the deflection range from zero to 0.093 ddm, the deflection shall be within 10 percent of being proportional to the difference in depth of modulation of the 90 and 150 cps signals, or the deflection shall be within 5 percent of Standard Deflection of being proportional to the difference in depth of modulation, whichever is greater. Additionally, as the difference in depth of modulation is increased beyond that producing full scale deflection to a value of 0.4 ddm, the indicator deflection shall not decrease. These standards shall be met over the range of signal input level from 100 to 20,000 microvolts. In the case of Deviation Indicators utilizing pivoted pointers, angular linearity is implied.

NOTE: This test was added by an amendment to Fort Rucker's Plan of Test dated 14 September 1964, and because of the short time factor suitable test equipment was not available. The test could not be performed, therefore, because the depth of modulation of the 90 and 150 cps signals could not be varied independently on the test equipment provided.

2.20 ILS LOCALIZER ALARM SIGNAL

2.20.1 Objective

To determine whether the flag alarm signal device is operative in the localizer (LOC) mode.

2.20.2 Criteria

2.20.2.1 The alarm signal device shall be plainly visible in the absence of an RF signal and visible in the absence of 90 and 150 cps modulation on a 1000-microvolt carrier at center response frequency.

2.20.2.2 The alarm flag shall at least begin to appear when the percentage modulation of the 90 and 150 cps signal of a standard localizer centering signal is reduced to 10 percent of each and when the percentage modulation of either the 90 or 150 cps signal is zero and the other 20 percent.

2.20.2.3 The alarm signal shall at least begin to appear when the level of a standard localizer deviation signal produces 50 percent of standard deflection of the deviation indicator.

2.20.2.4 The alarm signal shall be energized and its indicator off or out of sight when the level of a standard localizer test signal is varied over the range of at least 40 to 20,000 microvolts.

2.20.3 Method

Apply to the receiver input a standard localizer test signal having a level of 1000 microvolts. Determine the position or response of the alarm signal under the following conditions:

a. When the RF signal is removed.

b. When the 90 and 150 cps modulation is removed from the carrier.

c. When the modulation percentages of the 90 and 150 cps signals are 10 percent each.

d. When the level of the standard localizer deviation signal is that which produces 50 percent of standard deflection.

e. When the level of the standard localizer test signal is varied over the range from 40 microvolts to 20,000 microvolts.

2.20.4 Results

See Table XII.

2.20.5 Analysis

The criteria were fulfilled for all tests which could be performed on the 3 sets. It was not possible to independently vary the percentage modulation of the 90 and 150 cps signals because of the limitations of the test equipment.

TABLE XII. ILS LOCALIZER ALARM SIGNAL

Flag Alarm Signal Visible	Salmon	Aqua	Maroon
1. In absence of RF signal	Yes	Yes	Yes
2. In absence of 90 and 150 cps modulation	Yes	Yes	Yes
3. When the percentage modulation of the 90 and 150 cps signal is reduced to 10 percent of each	Yes	Yes	Yes
4. When the level of the localizer test signal is reduced to a value which produces 50 percent of standard deflection of the deviation indicator	Yes	Yes	Yes
5. When the level of the localizer test signal is varied over the range of 40 to 20,000 microvolts	No	No	No

2.21 PHYSICAL CHARACTERISTICS

2.21.1 Objective

[illegible] the weight, dimensions, and other physical characteristics of each test item.

2.21.2 Criteria

The equipment shall be of practical size and weight suitable for installation in any Army aircraft. The weight of the radio receiver, radio control, mounting, and indicator (less antenna and cabling) must not exceed 26 pounds, and the volume must be less than 1200 cu in.

2.21.3 Method

Each component of the test items was weighed and measured in accordance with the English system.

2.21.4 Results

See Table XLI.

2.21.5 Analysis

All the sets satisfied the size and weight criteria established in paragraph 2.21.2 above. The volume measurements were calculated from overall dimensions (including knobs, cable connections, etc.) when the individual components were mounted as they will be installed in the aircraft.

TABLE XIII. PHYSICAL CHARACTERISTICS

	Height (in.)	Width (in.)	Depth (in.)	Volume (cu in.)	Weight (lb)
Salmon					
Shock Mount Navigation Unit	5-1/4	5-1/2	12-3/16	351.9	11
Control Unit	2-1/2	5-3/4	6-3/8	91.6	2-1/6
Course Indicator	3-1/4	3-1/4	3-13/16	40.3	1-1/2
Total				483.8	14-9/16
Aqua					
Receiver Navigation Unit Shock Mount	9-1/8	5-1/8	16-1/4	759.9	19-1/2
Control Unit	1-7/8	5-3/4	6	64.7	1-3/8
Course Indicator	3-1/4	3-1/4	7-1/4	76.6	1-7/8
Total				901.2	22-3/4
Maroon					
Receiver Converter Converter, RMI Shock Mount	7-1/2	9-3/16	14-7/16	994.8	18-3/16
Control Unit	3-9/16	2-3/4	7-1/8	69.8	1-5/16
Course Indicator	3-1/4	3-1/4	6-9/16	69.3	2-7/16
Total				1133.9	21-15/16

SECTION 5. APPENDICES

APPENDIX I -- REFERENCES

1. Letter, Assistant Secretary of the Army (ASA), Installation and Logistics (Mr. Ignatius), 13 November 1963, subject: "FY 64 Procurement of Avionic Equipment," with 5 Indorsements thereto.

2. Department of Army Technical Manuals TM 11-2557-1, -24, and -25.

3. Department of the Army Project No. 1-G-6-41203-D-526 and USATECOM Project No. 4-4-4315-02, "Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets."

4. U. S. Army Electronic Command, Technical Requirement SCL 8014, 7 February 1964, "Receiver Set Radio, Units of (Replacement of AN/ARN-30( ))," with Amendment No. 2 dated 12 August 1964.

5. Letter, AMSEL-AV-E, Headquarters, U. S. Army Electronic Command, 24 February 1964, subject: "Modernization Program for Omni-Range Receivers, Automatic Direction Finding Equipment and Lightweight HF Aircraft Radio Sets," with one inclosure.

6. Letter, AMSTE-BG, U. S. Army Test and Evaluation Command, 17 March 1964, subject: "Test Directive, USATECOM Project No. 4-4-4315( ) Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets."

7. Memorandum for Record, STEBG-TPAV, U. S. Army Aviation Test Board, 15 April 1964, subject: "Test Requirements Conference, Military Potential (Comparative Evaluation) Test of the OMNI, ADF and HF Radios, USATECOM Project No. 4-4-4315/4316/4317."

8. Memorandum for Record, STEBG-TPAV, U. S. Army Aviation Test Board, 29 April 1964, subject: "USAECOM/USATECOM Planning Conference for Military Potential Test of OMNI, ADF and HF Radios, USATECOM Project No. 4-4-4315/4316/4317."

9. Message, USAECOM, AMSEL-RD-SRI-5-27, 6 May 1964, subject: "Confirming Telephone Message to Maj Treece on 1 May 1964 Regarding Military Potential Test of OMNI and ADF Receivers."

10. U. S. Army Test and Evaluation Command letter AMSTE-BG, 22 May 1964, subject: "Supplement Test Directive, USATECOM Project No. 4-4-4315( ), Military Potential Test (Comparative Evaluation) of Omni-Range Receivers."

11. U. S. Army Aviation Test Board Plan of Test, 15 June 1964, subject: "Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets." as revised.

12. U. S. Army Aviation Test Board Message STEBG-PR, 19 June 1964, subject: "Comparative Evaluation OMNI and ADF Navigation Equipments."

13. Minutes of Conference Held at USAECOM, Ft Monmouth, N.J., 1-2 July 1964, subject: "Evaluation of Commercial Equipment to Replace the AN/ARN-30 OMNI and AN/ARN-59 ADF Radio Sets."

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HEADQUARTERS
U. S. ARMY TEST AND EVALUATION COMMAND
Aberdeen Proving Ground, Maryland 21005

AMSTE-BG 17 Mar 1964

SUBJECT: Test Directive, USATECOM Project No. 4-4-4315( )
Military Potential Test (Comparative Evaluation) of
Omni-Range Receiver Sets

TO: President, U. S. Army Aviation Test Board, Fort Rucker
Alabama 36362
Commanding General, U. S. Army Electronic Proving
Ground, Fort Huachuca, Arizona 85613
Commanding Officer, U. S. Army Aviation Test Activity,
Edwards Air Force Base, California

1. References:

a. Letter, AMSEL-AV-E, Hq USAECOM, dtd 24 Feb 64, subject: Modernization Program for Omni-Range Receivers, Automatic Direction Finding Equipment and Lightweight HF Aircraft Radio Set, with 1 Incl. (Incl 1)

b. Department of Army Technical Manual TM 11-5826-207-24.

2. Description of Materiel: The Omni-Range Receivers are airborne radio receiving sets with a frequency range of 108 to 135 megacycles and designed to receive signals transmitted by VOR, VAR or localizer ground stations. The received signal is converted into usable information and presented on display indicators to provide the operator with navigation information.

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3. Background: For the past eleven years the Omni-Range Receiver AN/ARN-30 has been procured from one company. During this period no tests have been conducted to determine if the design of the receiver is abreast of the current state of the art. By direction of Assistant Secretary of Army, future procurement will be made by competitive selection with the objective to foster competition which will result in new and modernized equipment for the Army.

4. Test Objective: To conduct a military potential test (comparative evaluation) of commercially designed Omni-Range Receivers with the purpose of developing test data for use as a basis for selection of the most promising or suitable system or systems for Army use.

5. Responsibilities:

a. U. S. Army Aviation Test Board

(1) Executive Test Authority.

(2) Prepare and publish plan of test and report of test.

(3) Review specifications and available data to determine what test will be required to evaluate receivers.

(4) Conduct such tests and tasks as required to establish degree to which each receiver meets Army requirements.

b. U. S. Army Electronic Proving Ground

(1) Participating Test Authority.

(2) Review available engineering test data concerning the equipment to determine what engineering tests will be required to evaluate receivers.

(3) Assist as necessary in preparation of plan of test and report of test.

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(4) Conduct engineering test as required.

c. U. S. Army Aviation Test Activity

(1) Participating Test Authority.

(2) If required, assist in preparation of test plan and report.

(3) Review specifications and available test data to determine what flight testing will be needed to qualify the equipment.

(4) If required, conduct flight tests to establish performance and airworthiness.

6. Coordination: Close coordination will be effected with the U. S. Army Electronics Command, U. S. Army Electronics Research and Development Laboratories and appropriate USACDC agencies in the planning and execution of the test program.

7. Special Instructions:

a. When Omni Receivers are available for test, they will be supplied by USAECOM.

b. At completion of program, USAECOM will provide equipment disposition instructions.

c. Cost of equipment will not be considered in testing and will not be used in findings or recommendations of the final report.

d. USATECOM Project Numbers assigned:

(1) USAAVNTBD - 4-4-4315-01

(2) USAEPG - 4-4-4315-02

(3) USAATA - 4-4-4315-03

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d. This is a category II test and will be funded by the Commodity Command (USAECOM).

8. Test Plans and Reports:

a. Date for submission of test plan will be established at a coordination conference held by USAECOM.

b. Test Agencies will include with test plan an annex indicating agencies with whom plan was informally coordinated and their comments. If comments were not incorporated in test plan, state reason they were not.

c. Test report will be submitted in accordance with USATECOM regulations 705-2, 705-7 and 705-11.

9. Security: This equipment and associated correspondence are unclassified.

FOR THE COMMANDER:

/s/ Roger W. Kemp
/t/ ROGER W. KEMP
Colonel GS
C, Admin Office

5 Incls
1. as
2. Evaluation Criteria for ARN-30 Replacement
3. Scope of Flight Test for ARN-30 Replacement
4. Receiving Set ARN-30 Replacement
5. Proj Trans Sheets

Copies furnished:
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HEADQUARTERS
U. S. ARMY TEST AND EVALUATION COMMAND
Aberdeen Proving Ground, Maryland 21005

AMSTE-BG 22 May 1964

SUBJECT: Supplement Test Directive, USATECOM Project No. 4-4-4315 ( ), Military Potential Test (Comparative Evaluation) of Omni-Range Receivers

TO: Commanding General, U. S. Army Electronics Proving Ground, Fort Huachuca, Arizona 85613
Commanding Officer, U. S. Army Aviation Test Activity, Edwards Air Force Base, California 93523
President, U. S. Army Aviation Test Board, Fort Rucker, Alabama 36362

1. Reference:

a. Test Directive, USATECOM Project No. 4-4-4315, dated 17 March 1964, subject as above.

b. Letter, AMSEL-AV-E, dated 14 May 1964, subject: "Modernization Program for Omni-Range Receivers," Incl 1.

c. Message, AMSEL-RD-SRI-5-27, dated 6 May 1964, Incl 2.

2. Paragraph 4 of the original test directive, reference a, is revised to include the AN/ARN-30 in the military potential test (comparative evaluation) of commercially designed omni-range receivers. This additional requirement was requested by reference b.

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AMSTE-BG 22 May 1964

SUBJECT: Supplement Test Directive, USATECOM Project No. 4-4-4315 ( ), Military Potential Test (Comparative Evaluation) of Omni-Range Receivers

3. The plan of test and final report must include, within acceptable limits, the in-flight accuracy, range and reliability of the AN/ARN-30.

4. Cost of additional testing will be funded by the Commodity Command (USAECOM).

FOR THE COMMANDER:

ROBERT A. BAILEY
1st Lt, AGC
Asst Admin Officer

2 Incl
as

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(w/Incl)

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APPENDIX III -- FINDINGS

S - Salmon
A - Aqua
M - Maroon

TEST	REQUIREMENT	COMPLIANCE SCL 8014	COMPLIANCE TSO's C36a, C38b, and C40a	REMARKS
2.1	Safety	N/A	N/A	No safety hazards were found on any set.
2.2	Warm-up Time	N/A	N/A	All sets had a fast warmup. The Salmon set had an almost instantaneous warm-up.
2.3	Design Features	S: Complies A: Complies M: Does not comply	N/A	Maroon set did not have a push-to-test function.
2.4	Effect of Input Voltage Variations on Receiver Power	All comply	N/A	
2.5	Power Drain	None comply	N/A	All sets drew more AC power than permissible.

TEST	RECUIREMENT	COMPLIANCE SCL 8014	COMPLIANCE TSO's C36a, C38b, and C40a	REMARKS
2.6	Audio Frequency Response	All comply	All comply	
2.7	Receiver Sensitivity	All comply	All comply	
2.8	Automatic Volume Control	All comply	All comply	
2.9	Audio Output Distortion	S: Complies A. Does not comply M: Does not comply	All comply	For the Aqua and Maroon sets, distortion in the navigation channels with load impedance of 150 ohms was greater than permissible.
2.10	Gain	S: Complies A: Does not comply M: Complies	All comply	The Aqua set did not meet the SCL requirement on the navigation channels and on the communications channels with 85% modulation. The gain of the Maroon set was considerably greater than the SCL requirement.
2.11	Channel Selection Time	All comply	All comply	

TEST	REQUIREMENT	COMPLIANCE SCL 8014	COMPLIANCE TSO's C36a, C38b, and C40a	REMARKS
2.12	Spurious Sidebands	None comply	None comply	Spurious sidebands were detected on all sets. There was only one undesirable frequency found for the Aqua set.
2.13	Noise Level	S: Complies A: Complies M: Does not comply	S: Complies A: Complies M: Does not comply	On the Maroon set, the signal-plus-noise-to-noise ratio at low input signals did not meet the requirement.
2.14	Bearing Accuracy	All comply	All comply	The Maroon set indicated zero bearing error.
2.15	Deflection Linearity	None comply	None comply	Throughout the range of 0^{o} to 10^{o} phase difference, needle deflection for all sets was not linear. The Maroon set was the closest to being linear.
2.16	Flag Alarm	S: Does not comply A: Complies M: Complies	S: Does not comply A: Complies M: Complies	On the Salmon set, the flag alarm signal did not appear during loss of the 30-cps modulation of the VOR signal.

TEST	RECUIREMENT	COMPLIANCE SCL 8014	COMPLIANCE TSO's C36a, C38b, and C40a	REMARKS
2.17	Instrumentation Output	All comply	N/A	
2.18	Squelch Control	None comply	N/A	The Salmon set had no external squelch control. The Aqua and Maroon sets failed to operate correctly with the squelch control in the threshold position.
2.19	ILS Localizer Receiver	N/A	N/A	The test could not be performed because of limitations of the test equipment.
2.20	ILS Localizer Alarm Signal	All comply	All comply	
2.21	Physical Characteristics	All comply	N/A	The Salmon set was considerably smaller and lighter than the requirement.

PART B

USAHEL REPORT

(Not available at this time; will be submitted at a later date.)

SECTION 4

APPENDICES

APPENDIX I - OMNI MAINTENANCE TEST DATA

1. AQUA.

Aqua operated 281 hours during the test period. Four electronic sub-component failures occurred, none of which were related or repetitions. All of the defective sub-components were commonly-used circuit components of a normally reliable nature.

Failure	Maintenance Man-Hours* Org.	Maintenance Man-Hours* Field	No. Parts Required
a. Failure of Transistor (Q-101) type CK 919 or CT 2663 in navigation unit, S/N 1882, caused loss of the reference phase signal and resulted in loss of OMNI presentation. System time at failure - 11.3 hours.	0.9	2.6	1
b. Intermittent failure of Transformer (T-402), P/N L-2088641-1, in navigation unit, S/N 1882, caused the loss of 400 cycle servo signal and resulted in loss of OMNI presentation. System time at failure - 18.2 hours.	0.5	.6	1
c. Loss of proper connection on Wafer (S-2A) in control panel, S/N 1200, resulted in loss of frequency selection. Transistor (Q-401) 2N525, in receiver unit, S/N 1003, was found to be shorted causing loss of audio signal. System time at failure - 24.9 hours.	0.9	3.5	1

*In each case only one man was required to perform maintenance.

Failure	Maintenance Man-Hours* Org.	Field	No. Parts Required
d. Intermittent change of capacity of Capacitor (C-116), P/N L-2088302-1, in navigation unit, S/N 1882, caused an erroneous shift in the reference phase channel resulting in unreliable OMNI presentation. This discrepancy occurred intermittently during several flights. Subsequent flight line and bench checks failed to reveal source of problem. Unit was subjected to freezing environments and failures occurred which were traced to C-116.	1.5	5.0	1
TOTALS	3.8	11.7	4

2. MAROON.

Maroon operated 281 hours during the test period. No failures occurred.

3. SALMON.

Salmon operated 294 hours during the test period. The one failure which occurred is considered isolated and not subject to repetition.

Failure	Maintenance Man-Hours* Org.	Field	No. Parts Required
Mechanical misalignment of whole megacycle control shaft in control panel resulted in intermittent system operation. Whole megacycle [illegible] were not making positive contact causing receiver to mistune.	1.3	1.6	0

*In each case only one man was required to perform maintenance.

4. ANALYSIS.

Salmon and Maroon were more reliable than Aqua. However, analysis of Aqua's failures does not indicate a reliability problem over an extended operational period.

APPENDIX II - DEFICIENCIES AND SHORTCOMINGS

Definitions of these terms, according to USATECOM Regulation 705-7, are quoted herein for information:

"Deficiencies: Deficiencies are defects or malfunctions discovered during the life cycle of an equipment that constitute a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicate improper design or other cause, which seriously impairs the equipment's operational capability. A deficiency normally disables or immobilizes the equipment; or if occurring during test phases, will serve as a bar to type classification (AR 320-5)."

"Shortcomings: Shortcomings are imperfections or malfunctions occurring during the life cycle of an equipment which should be reported and which must be corrected to increase the efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the usability of the material or end product. If occurring during test phases, the shortcoming should be corrected if it can be done without unduly complicating the item or inducing another undesirable characteristic, such as increased cost, weight, etc. (AR 320-5)."

A. DEFICIENCIES.

Listed below are deficiencies noted during testing by the US Army Aviation Test Board, US Army Electronic Proving Ground, and US Army Human Engineering Laboratory.

1. Aqua:

Deficiency	Suggested Corrective Action	Remarks
a. System would not operate reliably at minimum reception altitude.	Undetermined.	None.

Deficiency	Suggested Corrective Action	Remarks
b. Lack of internal lighting in the course indicator caused difficulty in interpreting navigation information at night.	Install internal lighting.	None.
c. Too many turns were required to change course selection.	Alter gear ratio between course selector and radial indicator.	Seven and one-half turns of the course selector were required for the radial indicator to indicate a 180° change.
d. Warning flag lettering on the course indicator was too small for normal viewing.	Increase letter size to meet standard.	Applicable standards are contained in the USAHEL report.
e. Excessive rotor modulation occurred when equipment was installed in a helicopter.	Provide filters for specific helicopter in which equipment is installed.	Rotor modulation varies with rotor r.p.m., number of blades, and type of blades.
f. Controls were not labeled as to function and ganged knobs were of improper size.	Label all controls as to function and provide knobs that meet standard.	Applicable standards are contained in the USAHEL report.
g. Ganged controls did not have similar functions.	Combine whole megacycle and tenth megacycle controls. Combine On-Off and volume controls.	None.

Deficiency	Suggested Corrective Action	Remarks
h. Tuning knobs partially masked frequency dial.	Relocate tuning knobs below frequency dial.	Knobs were located on each side of frequency dial and masked the dial when viewed from either side.
i. Speech intelligibility was below the "normal" standard.	Improve speech intelligibility to at least the "normal" standard.	Applicable standards are contained in the USAHEL report.

2. Maroon:

Deficiency	Suggested Corrective Action	Remarks
a. System would not operate reliably at minimum reception altitude.	Undetermined.	None.
b. Control panel width was not standard.	Increase width to standard 5.75 inches.	Applicable standards are contained in the USAHEL report.
c. Controls were not labeled as to function and ganged knobs were not the proper size.	Label all controls as to function and provide knobs that meet standard.	Applicable standards are contained in the USAHEL report.
d. Controls and lettering were not illuminated.	Provide adequate illumination.	Applicable standards are contained in the USAHEL report.
e. Lack of internal lighting in the course indicator caused difficulty in	Install internal lighting.	None.

Deficiency	Suggested Corrective Action	Remarks
interpreting navigation information at night.		
f. Speech intelligibility was below the "normal" standard.	Improve speech intelligibility to at least the "normal" standard.	Applicable standards are contained in the USAHEL report.

3. Salmon:

Deficiency	Suggested Corrective Action	Remarks
a. Blue-yellow markings (used as an approach aid) were not provided on the course indicator.	Provide blue-yellow markings.	None.
b. Reciprocal bearing numerals on the course indicator were too small.	Increase size of numerals to standard.	Applicable standards are contained in the USAHEL report.
c. Lack of internal lighting of the course indicator caused difficulty in interpreting navigation information at night.	Provide internal lighting.	None.
d. Excessive rotor modulation occurred when equipment was installed in a helicopter.	Provide filters to remove rotor modulation.	Rotor modulation varies with rotor r.p.m., number of blades, and type of blades.
e. Control knobs on control panel were located too close together.	Comply with applicable standards contained in the USAHEL report.	None.

Deficiency	Suggested Corrective Action	Remarks
[illegible]. Ganged controls did not have similar functions and knobs were too small for use by operators wearing gloves.	Combine whole megacycle and tenth megacycle controls. Combine On-Off and volume controls. Increase size of control knobs to standard.	Applicable standards are contained in the USAHEL report.

B. SHORTCOMINGS.

Listed below are shortcomings discovered during USAAVNTBD evaluation. See parts A and B of section 3 for shortcomings discovered during the USAHEL and USAEPG tests.

1. Aqua.

Shortcoming	Suggested Corrective Action	Remarks
A.c. power was required for operation of the navigation unit.	Provide internal a.c. power supply in the navigation unit.	Lack of internal a.c. power for Aqua will preclude its use in aircraft not equipped with a.c. power supplies. In addition, a loss of a.c. power in aircraft equipped with a.c. power supplies would render the Aqua inoperative.

2. Maroon.

Shortcoming	Suggested Corrective Action	Remarks
Convertor unit was not compatible with integrated flight systems (AN/ASN-33).	Undetermined.	In its present configuration, Maroon will require a replacement convertor unit when used with an integrated flight system.

3. Salmon. No shortcomings were noted.

4. Installation of all test items.

Shortcoming	Suggested Corrective Action	Remarks
A degradation of performance occurred when two receivers (dual omni installation) were connected to a common antenna.	Provide an adequate impedance matching network to be used when connecting two receivers to a common antenna.	None.

APPENDIX III - DETAILED DESCRIPTION OF MATERIEL

1. AQUA. The Aqua omni-range system weighs 22 3/4 pounds and consists of four components:

a. Control Panel. The control panel is 1 7/8 inches high, 5 3/4 inches wide, and 6 inches deep. The front panel is edge lighted and contains all controls necessary for operation of the receiver and navigation units.

b. Course Indicator. The course indicator is 3 1/4 inches high, 3 1/4 inches wide, and 7 1/4 inches deep. The front of the indicator contains a vertical needle, horizontal needle, glide-slope flag, localizer flag, TO-FROM flag, omni-bearing selector control, and a digital type bearing indicator. The indicator has no internal lighting.

c. Receiver Unit. The receiver unit is 7 1/2 inches high, 2 1/2 inches wide, and 2 1/2 inches deep. The receiver has a transistorized unit with electrical-mechanical tuning and contains all electronic circuits necessary to receive VOR and localizer signals.

d. Navigation Unit. The navigation unit is 7 1/2 inches high, 2 1/2 inches wide, and 2 1/2 inches deep. The navigation unit is transistorized and contains all electronic circuits to convert the received VOR and localizer signals into the necessary signals to operate the course indicator and a radio magnetic indicator.

2. MAROON. The Maroon omni-range system weighs 22 pounds and consists of five components:

a. Control Panel. The control panel is 3 9/16 inches high, 2 3/4 inches wide, and 7 1/8 inches deep. The control panel is edge lighted and contains all controls necessary for operation of the receiver and two converter units.

b. Course Indicator. The course indicator is 3 1/4 inches high, 3 1/4 inches wide, and 6 9/16 inches deep. The front of the indicator contains a vertical needle, horizontal needle, compass card, glide-slope flag, localizer flag, TO-FROM flag, and an omni-bearing selection control. The indicator has no internal lighting.

c. Receiver Unit. The receiver unit is 7 1/2 inches high, 2 1/2 inches wide, and 14 7/16 inches deep. The receiver is approximately 80-percent transistorized with electrical-mechanical tuning and all electronic circuits necessary to receive VOR and localizer signals.

d. Converter Unit. The converter unit is 7 1/2 inches high, 2 1/2 inches wide, and 14 7/16 inches deep. The converter unit is approximately 73-percent transistorized and contains all electronic circuits to convert the received VOR and localizer signals into the necessary signals to operate the course indicator.

e. Converter Unit (RMI). The converter unit (RMI) is 7 1/2 inches high, 2 1/2 inches wide, and 14 7/16 inches deep. This unit is approximately 87-percent transistorized and contains all electronic circuits to combine the converter signals (described in d above) with aircraft heading signals. The resultant signal operates a radio magnetic indicator.

3. SALMON. The Salmon omni-range system weighs 14 1/2 pounds and consists of three components:

a. Control Panel. The control panel is 2 1/2 inches high, 5 3/4 inches wide, and 6 3/8 inches deep. The front panel is edge lighted and contains all controls necessary for operation of the VOR/LOC/RMI navigation unit.

b. Course Indicator. The course indicator is 3 1/4 inches high, 3 1/4 inches wide, and 3 13/16 inches deep. The front of the indicator contains a vertical needle, horizontal needle, compass card, glide-slope flag, localizer flag, TO-FROM flag, and an omni-bearing selector control. The indicator has no internal lighting.

c. VOR/LOC/RMI Navigation Unit. The navigation unit is 5 1/4 inches high, 5 1/2 inches wide, and 12 3/16 inches deep. This unit is completely solid-state and contains all the electronic circuits for VOR, LOC, and RMI operation.

APPENDIX IV - COORDINATION

The following agencies participated in the review of the final report:

US Army Combat Developments Command Aviation Agency

US Army Aviation School

US Army Electronic Proving Ground

APPENDIX V - DISTRIBUTION LIST

Agency	No. Copies
Commanding General US Army Test and Evaluation Command ATTN: AMSTE-BG Aberdeen Proving Ground, Maryland 21005	2
Commanding General US Army Electronics Command ATTN: AMSEL-AV-G Fort Monmouth, New Jersey 07703	25

AD________________________________ Accession No.____________________
US Army Aviation Test Board, Fort Rucker, Alabama, Report of USATECOM Project No. 4-4-4315-01, Military Potential Test (Comparative Evaluation) of Omni-Range Receiver Sets, 4 January 1965. DA Project No. 1G641203D526. 110 pp., 3 illus., FOR OFFICIAL USE ONLY. It was concluded that all of the systems tested should be suitable for Army use when the deficiencies are corrected; that of the systems tested, Salmon has the greatest and Maroon the least military potential; that technical requirements used were not a satisfactory standard for technical evaluations; and that correction of the shortcomings would enhance the suitability of the test items. It was recommended that the deficiencies be corrected and the selected system undergo further testing before acceptance by the Army as a standard item; the shortcomings be corrected as technically and economically feasible; and the technical requirements be revised to provide clear, realistic specifications in keeping with the state of the art in airborne navigation equipment.

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CODE SHEET

This code sheet will be removed from the report when loaned or otherwise distributed outside the Department of Defense.

Code	Manufacturer
Aqua	Bendix Corporation
Maroon	Aircraft Radio Corporation
Salmon	Collins Radio Corporation